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SID 62-52

COMMAND MODULE
PERFORMANCE AND INTERFACE
PRELIMINARY SPECIFICATION
PROJECT APOLLO SPACECRAFT

(Unclassified)
NAS 9-150

~~Revised 15 May 1962~~
~~Ø Denotes Change~~

Approved by

J. W. Paup
Vice President and Apollo Program Manager

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

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SUMMARY OF CHANGES

The following changes have been made to SID 62-52, dated 28 February 1962, to make this revision, dated 15 May 1962. The changes have been made in accordance with NASA letter to Mr. John Paup, dated 21 March 1962.

TABLE I.

"Max g" and "Max g abort" have been changed to "Max q" and Max q Abort" in the first column. Also, in the first column, the word, "Entry" has replaced the word, "Reentry." In the second column, the word, "Time" has replaced the word, "Mode", and the asterisked explanatory note has been added. In the Po column, the numbers "14.5" and "14.4" have replaced the numbers "14.7" and "14.7" respectively.

TABLE II.

"Max g" and "Max g Abort" have been changed to "Max q" and "Max q Abort" in the first column. Also in the first column, the word, "Entry" has replaced the word, "Reentry." In the second column the word, "Time" has replaced the word, "Mode", and the asterisked explanatory note has been added.

CONTENTS

ILLUSTRATIONS

1. SCOPE

1.1 Scope. - This specification covers the performance and interface requirements of the Command Module of the Apollo Spacecraft. The Command Module shall house and support a three man crew and shall serve as the Spacecraft command center.

2. APPLICABLE DOCUMENTS

2.1 General. - The following documents form a part of this specification.

Government Documents

MIL-Q-9858	Quality Control System Requirements, dated 9 April 1959
NCP 200-2	Quality Assurance Provisions for Space System Contractors, dated 15 December 1961

North American Aviation, Inc., Space and Information Systems Division

SID 62-51	Spacecraft Performance Specification, dated 28 February 1962
SID 62-53	Service Module Performance and Interface Specification, dated 28 February 1962
SID 62-57	GSE Performance and Interface Specification, dated 28 February 1962
SID 62-65	Design Criteria Specification, dated 28 February 1962
SID 62-76	GOSS Performance and Interface Specification, dated 28 February 1962
SID 62-78	Parachute Recovery (Earth Landing) System Performance Specification
SID 62-81	Crew Systems Performance Specification

SID 62-82	Environmental Control System Performance Specification
SID 62-83	Electrical Power System Performance Specification
SID 62-84	Navigation and Guidance Subsystem Specification
SID 62-85	Stabilization and Control Subsystem Specification
SID 62-86	Communications and Instrumentation Performance Specification
SID 62-88	Launch Escape System Performance Specification
SID 62-240	General Requirements for Preparation for Delivery of Apollo Airborne Equipment

3. REQUIREMENTS

3.1 General. - The Apollo Spacecraft shall be composed of separable modules as described in Specification SID 62-51, Spacecraft Performance Specification and illustrated in Figure 1. The Spacecraft shall include a recoverable Command Module which shall remain essentially unchanged for all Apollo missions. All crew-initiated control functions shall be exercised from the Command Module. The Command Module, as far as practicable, shall contain the Spacecraft communication, navigation, guidance, control, computing, and display equipment. Other equipment required during nominal and/or emergency landing phases shall also be included in the Command Module.

3.2 Performance Characteristics. - The performance of the Command Module shall be as specified herein and in the Spacecraft Performance Specification, SID 62-51, under the conditions set forth in the Design Criteria Specification, SID 62-65.

3.2.1 Crew Systems. - Crew Systems shall be as described in Specification SID 62-81, Crew Systems Performance Specification.

3.2.1.1 Couch. - Each crewman shall be provided with a support couch with protection against acceleration loads. Couches shall be constructed to enable crewmen to interchange positions. All couches shall be easily removable for the purpose of preflight and inflight maintenance.

3.2.1.1.1 Restraint. - A restraint system shall be provided with each couch. The system shall allow the interchange of crewmen with simple attachment and adjustment for comfort and sizing. The restraint system shall provide adequate restraint for all nominal and emergency flight phases.

3.2.1.1.2 Impact Attenuation. - Impact attenuation beyond that required to maintain general Spacecraft integrity shall be obtained through use of discrete shock mitigation devices for the crew support and restraint equipment.

3.2.1.1.3 Vibration Attenuation. - Vibration attenuation beyond that required to maintain general Spacecraft integrity shall be provided with each support and restraint system. Such vibration attenuation devices shall keep vibration loads transmitted to the crew within tolerance limits and also permit the crew to exercise necessary control and monitoring functions.

3.2.1.2 Pressure Suits. - Pressure suits shall be provided for extra-vehicular operations and for crew protection in the event of cabin decompression.

3.2.1.3 Sanitation. -

3.2.1.3.1 Human Waste. - The Spacecraft shall have a toilet for collection of urine and fecal waste. The collection system shall include means for disinfecting human waste sufficiently to render it harmless and unobjectionable to the crew.

3.2.1.3.2 Personal Hygiene. - The Spacecraft shall be equipped with facilities for shaving, dental cleansing, body cleansing, and deoderizing.

3.2.1.3.3 Non-Human Waste. - The Spacecraft shall have provisions for handling of all other waste such as those from eating and personal hygiene.

3.2.1.3.4 Control of Infectious Germs. - The Spacecraft systems operation shall provide means for controlling infectious organisms which would have an unfavorable effect upon the crew members.

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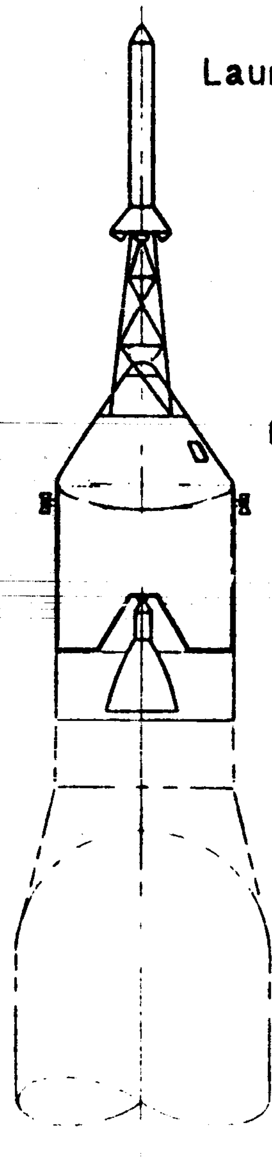


Figure 1. General Arrangement Earth Orbital, Circumlunar, and Lunar Orbital Configuration

[redacted]

3.2.1.4 Food and Water. -

3.2.1.4.1 Food. - All food shall be dehydrated, freeze-dried, or similar type that is reconstituted with water or does not need reconstitution.

3.2.1.4.2 Water. - Hot and cold water shall be provided by the environmental control system (ref paragraph 3.2.8.5). In addition, sufficient water must be on board at launch to provide the 72 hour landing requirement in event of early abort.

3.2.1.5 Emergency equipment. -

3.2.1.5.1 Survival Equipment. - Post-landing survival equipment shall include one three man life raft, food, location aids, first aid equipment, and various accessories necessary to support the crew outside the Spacecraft for three days in any possible emergency landing area.

3.2.1.5.2 Personal Parachutes. - Each crewman shall be equipped with a personal parachute for use in the event that the Spacecraft landing system malfunctions, cannot function, or cannot cope with local hazards. The personal parachute shall be stowed in the back of the seat of each couch. The restraint harness shall serve as the parachute harness.

3.2.1.5.3 First Aid Equipment. - The Spacecraft shall be equipped with first aid and preventive medicine items for coping with various human injuries and disorders.

3.2.1.5.4 Radiation Dosimeters. - Each crew member shall be provided with an accurate, simply read, personal dosimeter system.

3.2.1.6 Medical Instrumentation. -

3.2.1.6.1 Physiological Measurements. - Ultimate monitoring and telemetry requirements shall be specified in a later revision of this specification.

3.2.1.6.2 Extra-Vehicular Operations. - During lunar exploration or manned extra-vehicular pressure suit operations, information shall be transmitted from the extra-vehicular suit and monitored within the Spacecraft.

3.2.1.7 Recreation. - Provisions shall be made for crew recreation. (Ref. SID 62-81)

[redacted]

3.2.1.8 Sleeping. - Provisions shall be made for one crewman at a time to sleep without undue distractions.

3.2.2 Communications and Instrumentation System. - The Communications and Instrumentation Systems shall be as described in Specification SID 62-86 and shall consist of communications, instrumentation, and data systems. Flexibility for incorporation of future additions or modifications shall be stressed throughout the design and assembly of the system.

3.2.2.1 Communications System. - The Command Module Communications System shall provide the following functions:

(a) Two-way voice communication between crew members and the ground stations

(b) Reliabile tracking signals in the near earth phase of the flight

~~(c) Radio recovery aids~~

(d) Spacecraft to ground data transmission

(e) Personal communication provided for internal and external two-way voice

3.2.2.2 Instrumentation System. - The Instrumentation System shall detect, measure, and display all parameters required by the crew for monitoring and evaluating the integrity and environment of the Spacecraft and performance of Spacecraft systems. The system shall provide the following:

(a) Displays and controls to enable the crew to monitor and control the Spacecraft systems

(b) Data for transmission to earth, and information for abort decision, as required

(c) Recording equipment for telemetry and voice information

(d) Photographic equipment for internal and external use

(e) A telescope for lunar surface and celestial body studies

(f) In-flight-test instrumentation to provide the crew a gross indication of the go-no-go condition of the Spacecraft critical systems.

(g) Television for monitoring internal and external scenes for real time viewing on board and at earth stations.

3.2.3 Navigation and Guidance System. - The Navigation and Guidance System as described in Specification SID 62-84, shall provide:

(a) A primary Spacecraft attitude reference

(b) A primary position and velocity resolving display, and control function

(c) Guidance predictions based on information computations

(d) Prelaunch checkout function

3.2.4 Stabilization and Control System. - The Stabilization and Control System, as described in SID 62-85, shall provide:

(a) Manual and automatic on-off control of command and service modules reaction control engine

(b) Manual and automatic positioning control for the gimballed engines of the Service and Lunar Landing Modules propulsion systems.

(c) Manual and automatic on-off thrust control of the Service propulsion engine(s).

(d) Manual and automatic throttle control of the Lunar Landing Module thrust systems.

(e) Launch escape system control.

(f) Standby inertial reference system.

(g) Output signals for display of vehicle angular attitudes and rates.

3.2.5 Launch Escape System. - The Command Module shall be provided with a Launch Escape System as described in Specifications SID 62-51, Spacecraft Performance Specification, and SID 62-88, Launch Escape

System Performance Specification, and located as shown in Figure 1. The Launch Escape System shall separate and translate the Command Module from the Launch Vehicle in the event of failure or imminent failure of the Launch Vehicle during all atmospheric phases. The performance of the launch escape system shall be dictated by crew safety requirements and the structural capability of the Command Module to resist overpressures due to Launch Vehicle explosion. The crew sustained acceleration limit of 20 g shall not be exceeded.

3.2.5.1 <u>Escape System Jettison.</u> - For normal flight, the launch escape motor is used for tower jettison. For a launch pad or atmospheric abort condition, the launch escape motor is used for Command Module separation and the tower jettison motor is used to jettison the tower.

3.2.6 <u>Reaction Control System.</u> - The Command Module reaction control system is required for attitude control subsequent to separation from the Service Module. The reaction jets, upon receiving signals from the stabilization and control system, provide thrust to rotate the Command Module about three axes to perform (1) positioning prior to re-entry, (2) manuevering during re-entry, (3) stabilization of the module during deployment of the landing system and (4) positioning of the module for correct landing impact attitude. The system is required to safely return the Command Module from all phases of flight including pad and launch abort.

3.2.7 <u>Electrical Power System.</u> - The Electrical Power System of the Spacecraft shall be as described in Specification SID 62-83, Electrical Power System Performance Specification. The system shall supply, condition, and distribute all electrical power required by the Spacecraft for the full duration of the mission, including the post landing recovery period.

3.2.7.1 <u>Major Functions.</u> - The Electrical Power System shall be composed of the following functional divisions:

(a) Primary power shall be supplied by a fuel cell system located within the Service Module (ref Specification SID 62-53)

(b) Zinc-Silver oxide primary type batteries located within the Command Module shall provide primary power during the re-entry phase and supplement the fuel cell system during peak load in the emergency operating mode.

(c) A separate zinc-silver oxide primary type battery shall provide electrical power to the recovery system during the 72 hour recovery period.

(d) Static inversion devices shall provide the a-c power required by the Spacecraft systems.

(e) The Electrical Power System shall include display and control panels and a subsystem for distribution of generated power to electrical loads.

3.2.8 Environmental Control System. - The Environmental Control System shall control the temperature and atmosphere in the Command Module for crew and equipment. Environmental Control System equipment shall be as described in Specification SID 62-82, Environmental Control System Performance Specification. Major portions of the system are included in the Service Module (ref SID 62-53). The system shall control the following conditions in the Command Module:

Total cabin pressure (O_2 and N_2 mixture)

Relative humidity

Partial pressure CO_2

Temperature

Removal of particles

Noxious gas removal

3.2.8.1 Pressure Suit Circuit. - The pressure suit circuit shall automatically control the flow, pressure, temperature and composition of the pressure suit gas. Provision shall be made for the use of individual pressure suits.

3.2.8.2 Coolant Circuit. - A coolant circuit shall provide cooling of the potable water, the pressure-suit air, the cabin air, and the Command Module electronic equipment, during all mission segments except entry and earth landing.

3.2.8.3 Cabin Air Loop. - The cabin air loop shall provide atmospheric control for the Command Module during all phases of the mission including post-landing ventilation for the cabin, using inflow and outflow snorkels.

3.2.8.4 Oxygen Supply. - The principal supply of oxygen shall come from the storage system in the Service Module. During entry, after Command and Service Modules have separated, a pressurized gaseous oxygen supply located within the Command Module shall provide the required oxygen.

3.2.8.5 Water Supply. - The water supply subsystem shall consist of two parts: (a) a waste water system, and (b) a potable water system. The principal source of potable water is the electrical power system fuel cells in the Service Module. The Command Module shall contain an adequate supply of potable water to meet the crew's needs following an immediate abort and following normal landing.

3.2.8.6 Air Lock Pressurization. - The air lock pressurization subsystem consists of provisions for (a) venting the air lock to space from inside the closed lock; (b) pressurizing the lock from inside the closed lock or inside the cabin; (c) connection of back packs to the cryogenic oxygen supply; and (d) relief from excess pressure.

3.2.9 Earth Landing System. - The Earth Landing System shall be as described in Specification SID 62-78 and shall include drogue chutes, landing parachutes (or parawing), impact attenuation devices, and post landing location aids. The system shall satisfy the following requirements after normal entry, maximum dynamic pressure escape, and pad escape:

(a) Post-entry Stabilization. - Stabilize the Command Module during post-entry descent.

(b) Velocity Control. - Reduce the vertical velocity to a maximum of 30-feet per second at an altitude at 5000 feet.

(c) Impact Attenuation. - Reduce impact acceleration so that neither the Command Module primary structure nor flotation is impaired. Any further attenuation required by the crew shall be provided by individual crewman shock attenuation devices. The maximum emergency limit "g" Forces as specified in SID 62-65 shall not be exceeded for any landing regardless of capsule orientation.

(d) Landing Area. - Compatible with water and land recoveries.

3.3 External Design Load Envelope. - The Command Module shall withstand the variable and simultaneous dynamic environments resulting from normal and emergency missions as defined herein:

3.3.1 Pressure. - Command Module external pressures under typical extreme conditions are given in Table I.

3.3.2 Temperature. - Provision shall be made to prevent the outer surface of the heat shield substructure from exceeding 600 F. Provision shall be made to withstand the effects of limited damage to the ablation material.

3.3.3 Acceleration. - The load factors to which the Command Module shall be subjected under typical flight modes shall be as given in Table II. Simultaneous longitudinal and transverse load application shall be considered.

3.3.4 Vibration. - The Command Module shall withstand the structural vibration resulting from local response to acoustic excitation and coincident flight loads of up to 20 g (steep re-entry).

3.3.5 Acoustic Noise. - The Command Module shall withstand all acoustic excitation from the time of booster engine ignition to exit from the atmosphere and from time of atmospheric re-entry to earth landing. The noise spectrum will extend from 5 to 10,000 cps, with overall levels between 145 to 163 db for up to 2-1/2 minutes duration. Escape tower engine operation will cause an acoustic level of 166 db for a two second period.

3.4 Reliability. - The design goal for reliability of the Command Module shall be .960.

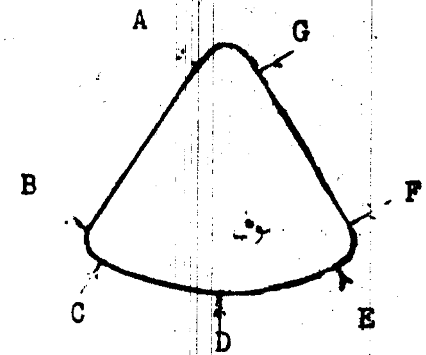
3.5 Configuration Parameters. -

3.5.1 Geometric. - The basic external geometry of the Command Module shall be established by aerodynamic and thermodynamic performance requirements, and shall be as shown in Figure 2. The Module shall be a symmetrical, blunt body developing a hypersonic L/D of approximately 0.50. The L/D vector shall be effectively modulated in hypersonic flight. The modulation shall be achieved through a designed center-of-gravity offset and roll control.

3.5.2 Weight. - Performance calculations shall be premised on a Command Module gross take-off weight of __________ pounds.

[redacted]

Ø Table 1. Command Module, Limit External Pressure
(Preliminary Information)



Condition	Time*	Po	A	B	C	D	E	F	G
		PSIA							
Pad Abort	1	14.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7
	2	14.5	17.5	17.5	14.2	14.2	14.2	17.5	17.5
	3	14.4	19.1	19.1	13.9	13.9	13.9	19.1	19.1
Max q		2.4	10.1	10.1 [1]				10.1 [1]	10.1
Max q Abort	1	3.4	8.5	8.5	1.0	1.0	1.0	8.5	8.5
	2	3.2	11.5	11.5	.8	.8	.8	11.5	11.5
	3	3.2	14.8	14.8	6.0	2.0	1.0	1.0	3.0
	4	3.2	2.2	2.2	11.2	14.8	11.2	2.2	2.2
	5	3.2	2.2	1.0	1.0	2.0	6.0	14.8	14.8
Entry		.01	0.5	0.5	9.2	13.4	16.0	.8	.8

1 Add 4.7 psi Buffet Pressure

* Selected time(s) during respective condition when significant pressure pattern exists.

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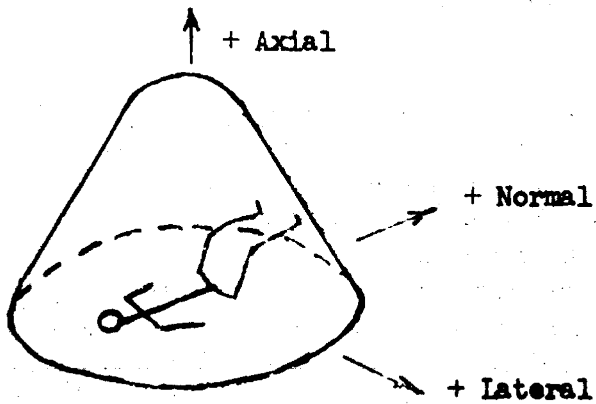
ø Table 2. Command Module, Limit Accelerations
(Preliminary Information)



Condition	Time*	Acceleration (G)		
		AXIAL	NORMAL	LATERAL
Pad Abort	1	+18	-.6	±.3
	2	+17.2	-.6	±.3
	3	0	-.4	±.2
Max q		+2.2	±.25	±.25
Max q Abort	1	+9	-.3	±.2
	2	-8	+.3	±.2
	3	-6	-8.6	±.1
	4	+13	0	0
	5	-6	+8.6	±.1
End Boost Stage 1 (EBSI)		+6.5	±2	
		+6.5	0	±2
Vacuum Abort		+19	-2	0
Entry		+20	-2.2	±.2
Lunar Touchdown		+6	±3	±3

* Selected time(s) during respective condition when significant pressure pattern exists.

3.5.3 Center-of-Gravity Management. - Consideration shall be given to the arrangement of water stores to permit center-of-gravity management. Alteration of crew positions shall be considered for center-of-gravity management where orientation with respect to displays and controls is not limited.

3.5.4 Ingress and Egress Hatches. - Three outward opening hatches shall be provided in the Command Module just above the crew's heads. Windows for maximum field of view shall be incorporated in these hatches. The three hatches shall provide the crew with individual bailout or other types of emergency egress without interfering with each other's activity. Normal ingress and egress for the crew and all onboard equipment installation shall be through the center hatch. Provision shall be made for aerodynamic fairing and protection of the hatches from flight environments.

3.5.5 Air-Lock. - The Command Module shall incorporate an air-lock for crew ingress and egress to and from the Command Module in the environment of space without loss of cabin pressure.

3.5.6 Docking Provision. - The Command Module shall include a docking device to lock together the Command Module and another spacecraft while in orbit.

3.6 Interface Requirements. - All mechanical, fluid, electrical, and electronic interfaces between the Command Module, Service Module, GOSS, and/or GSE shall perform their particular functions while maintaining compatible operation between portions of the respective system without deleteriously affecting other systems. A preliminary interface drawing is shown in Figure 3.

3.6.1 Service Module. - The umbilical devices between the Command and Service Modules shall be disconnected immediately prior to physical separation of the Command Module from the Service Module for any normal or abort mode.

3.6.1.1 Electrical. - The umbilical devices shall connect the circuitry necessary for integration of systems which are common to the Command Module and Service Module. Electronic signal characteristics shall be compatible between modules. Electro-interference shall be controlled in accordance with SID 62-65, Design Criteria Specification. Launch Vehicle propulsion, control, and structural abort information shall be provided to the Command Module instrument panel through this umbilical.

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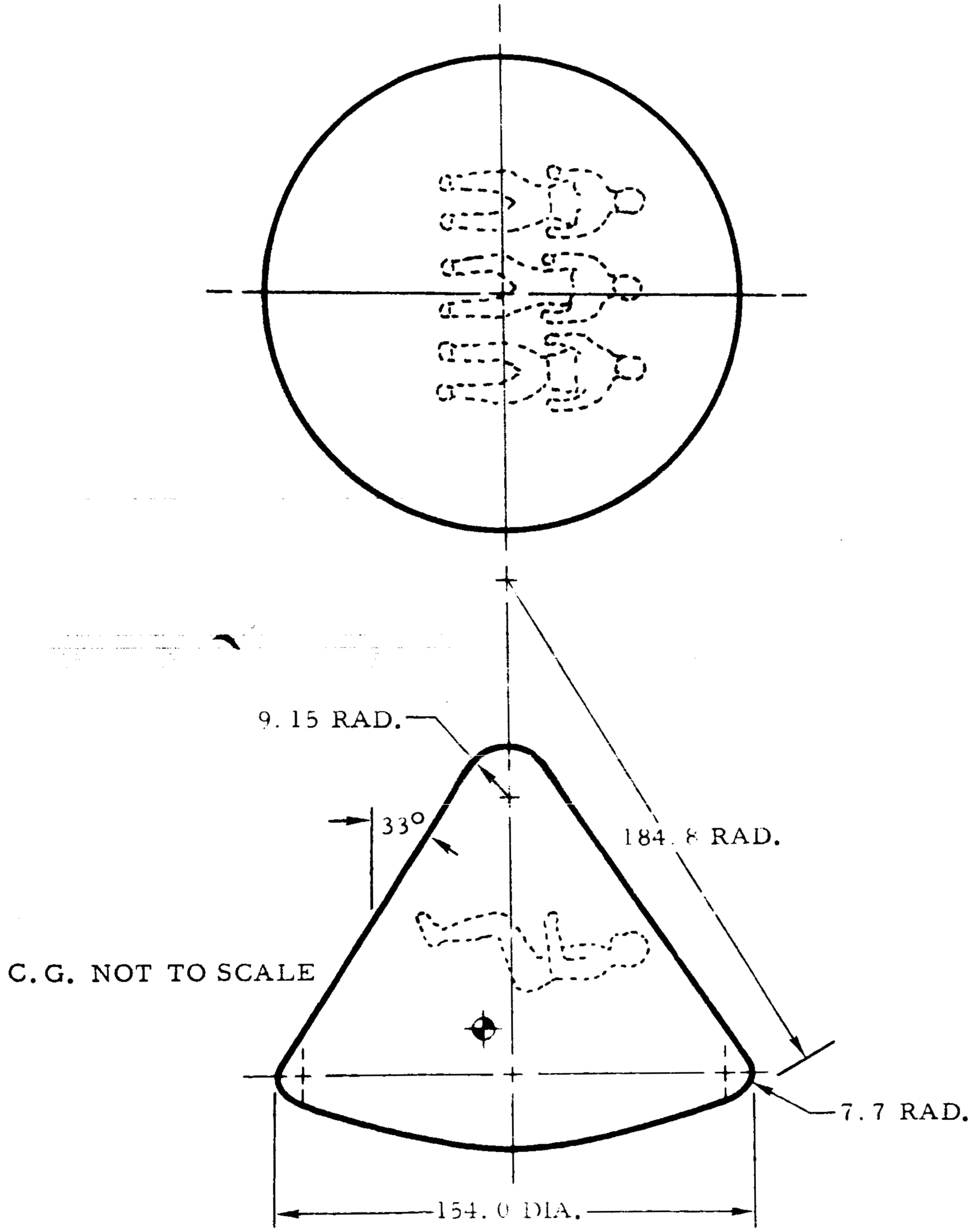

Figure 2. Command Module Nominal Geometry

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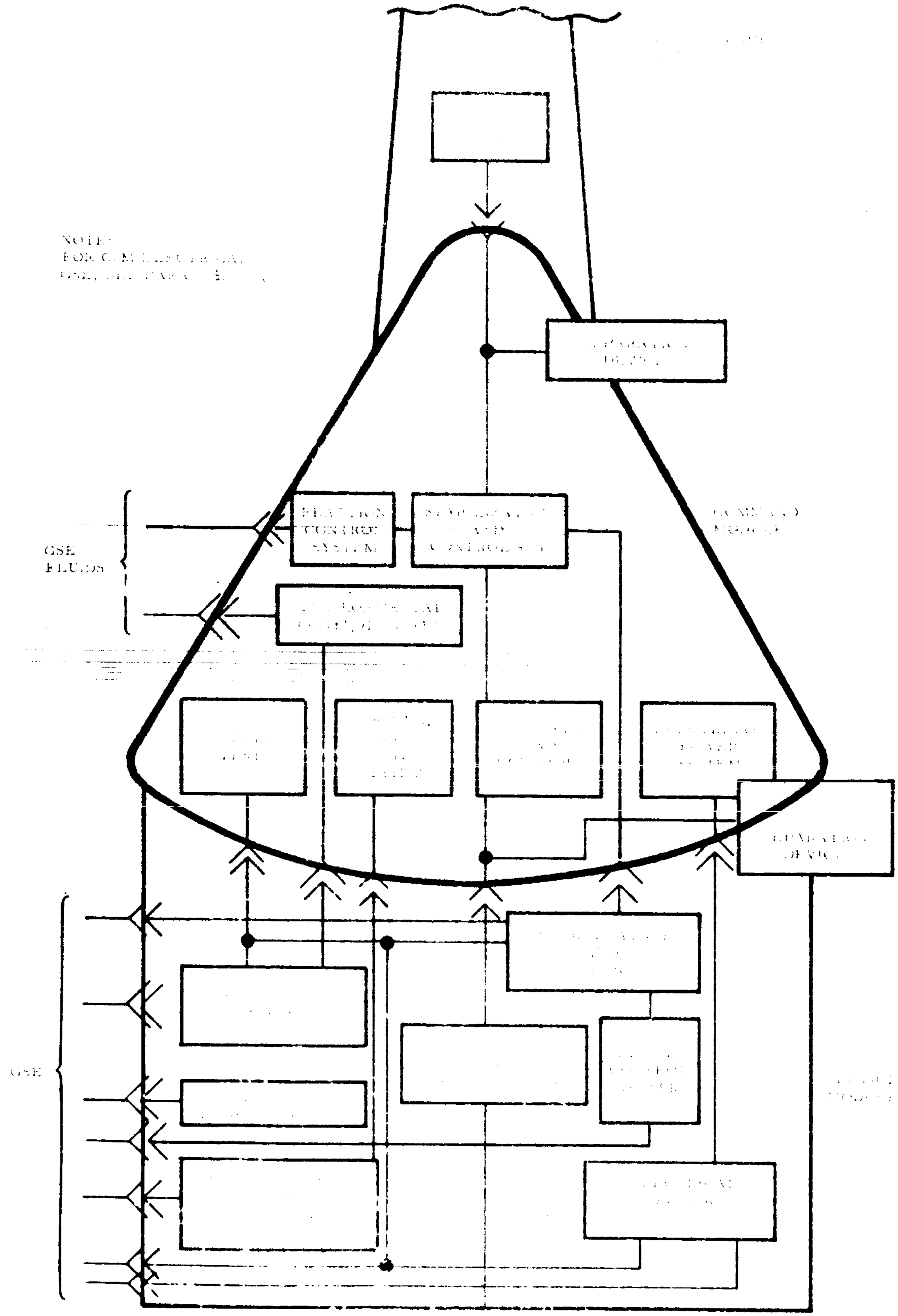

Figure 4. Preliminary Interface Block Drawing

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3.6.1.2 Mechanical. - Provisions shall be made for in-flight separation of the Service Module from the Command Module.

3.6.1.3 Fluids. - Suitable connection devices shall be provided in the umbilical to conduct liquids and gases between the Command and Service Modules. Provisions shall be made to prevent contamination of the disconnected lines and to ensure positive shutoff of flow. Contaminants shall not be introduced into the lines in the mating process.

3.6.2 Adapter. - Addenda shall be prepared which define the interface requirements between the Command Module and Adapter f specific missions without the Service Module.

3.6.3 Ground Operational Support System (GOSS). - The communication subsystems of the Command Module shall be compatible with GOSS for all phases of flight. (Ref SID 62-76, GOSS Performance and Interface Specification)

3.6.4 Extra-Vehicular Operations. - Two way voice communication shall be maintained with crew members operating external to the Command Module.

3.6.5 Ground Support Equipment. - (Ref: SID 62-57, GSE Performance and Interface Specification)

3.6.5.1 Electrical. - Provisions shall be made for connections to ground support equipment for receipt of input stimuli and transmittal of output responses. This includes the following points of access.

(a) Connection to the In-Flight Test and Maintenance System through the IFT&M programmer and converter.

(b) Connection into the Command Module to Service Module umbilical cable by interposing an adapter fitting between the two mating halves of the umbilical disconnect.

3.6.5.2 Mechanical. - The Command Module design shall provide attach points for support cradles, hoisting adapters, tie down fittings, and braces to maintain shape during transportation. Position indicators, such as protractors, shall attach to the module and transmit degree of motion of propulsion engines, ntennas, and any other motion devices. Weighing and alinement equipment shall be provided.

3.6.5.3 Fluids. - The ground support equipment and Command Module fluid system interfaces shall consist of fluid fill and return

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connections for coolants, propellants, helium, freon and oxygen. These materials, required for proper operation of the Spacecraft systems, necessitate clean, safe and reliable connection of the facility lines to the Command Module. The interface of each system shall be so located that inherent safety of equipment and operating personnel from toxic and corrosive effects is provided. The couplers which must be remotely separated shall be self-sealing.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. - The requirements specified in MIL-Q-9858 and NASA Quality Publication NCP 200-2 form a part of this specification. Inspections and tests to determine conformance of the article to contract and specification requirements shall be conducted prior to submission of the article to NASA or in the presence of an NASA representative. Results of inspection tests on major components shall be submitted to NASA for review. Other acceptance test data relative to this specification shall be maintained and made available for review by NASA upon request.

5. PREPARATION FOR DELIVERY

5.1 General. - Preparation for delivery of the Command Module shall be in accordance with Specification SID 62-240 which governs basic performance and environmental criteria for packaging, handling, and transportation of airborn items. The Command Module shall be preserved and packaged for transportation on transport dollies. All preservation and packaging methods shall be compatible with the module and shall be in consonance with delivery modes, destinations, and anticipated storage periods. For each item delivered separately from the module, an individual packaging and handling drawing shall detail methods or requirements for preservation, packaging, marking, loading, stowing, unpacking and handling.

6. NOTES